NOTES, ABSTRACTS, AND REVIEWS.

ON THE RELATION BETWEEN THE MOVEMENTS AND THE TEMPERATURES OF THE UPPER ATMOSPHERE.

By V. BJERKNES.

That the temperature of the lower layers of the atmosphere decreases from the Equator toward the poles is well known, as is also the cause of this decrease and its relation to the winds of the planetary circulation. Aerological investigations have disclosed the fact, however, that the temperature of the upper strata of the atmosphere increases from the Equator toward the poles.

That this latter phenomenon is a necessary consequence of the surface conditions may be shown by considering the earth and its atmosphere as one system, symmetrical with respect to the axis of the earth, around which the whole system rotates. From the well-known differential equations for the equipotential surfaces as modified by centrifugal force, it follows that in a stratum of air which has the same angular velocity as has the earth, the isobaric surfaces will coincide with "level" surfaces parallel to the surface of the earth; while if the angular velocity of the stratum be greater, these surfaces will not be parallel to the surface of the earth but will be more flattened along their polar diameters.

With the exception of a relatively thin intertropical zone, the westerly winds dominate the lower layers of the atmosphere, and hence in these layers the isobaric surfaces are ellipsoids which are more eccentric than the "level" surfaces. Now, as Laplace showed,[1] the atmosphere, assumed to be a fluid and limited by an upper boundary similar to the upper surface of the ocean, extends up to a certain lenticular surface symmetrical with respect to the polar axis of the earth and having an equatorial diameter of 6.6 that of the earth and a polar diameter of 4.4 that of the earth; if, as more recent investigations indicate, the atmosphere has no such limiting fluid surface, but extends out indefinitely beyond the point where attraction and centrifugal force become equal, then the isobaric surfaces approach the practically spherical form due to attraction alone; but in either case the upper air will move under the influence of the friction of the westerly winds of high latitudes and of the easterly winds of tropical regions, the latter exerting the same moment because of their greater distance from the terrestrial axis but relative thinness, the resultant being a movement of the upper air as a solid body with the angular velocity of the earth, so that the rotation of the earth itself can not be altered except by outside influences. Hence it is seen that the exaggerated ellipticities of the lower isobaric surfaces do not continue to extreme heights, but are gradually reduced.

As a consequence, it is at once evident from a diagram that near the surface of the earth the thickness of the stratum between two isobaric surfaces is greater at the Equator than at the poles; but in the upper air, greater at the poles than at the Equator. This thickness, of course, must vary as the specific volume, or as the temperature, of the air. Hence, from the observed wind movements alone, we are led to infer that the surface temperature must increase from poles to equator; but, further, *we must also infer that at sufficiently great heights the temperature increases from Equator to poles.*[2]—E. W. W.

THE ULTRA ATMOSPHERES.

By T. C. CHAMBERLIN.

The constitution of gases is a matter of great importance to meteorology and to cosmogony. Because of the rapid progress which has been made in our knowledge since the time of Laplace, the works of the latter on the atmospheres of the planets, including that of the earth, and on cosmogony, need revision.

The sun, by virtue of its superior attraction, rules the whole space of the solar system; there is merely reserved a small spheroid about each planet in which the attraction of the latter predominates. This "sphere of control" of the earth is a spheroid of three unequal axes, the minimum of which is about 1,000,000 kilometers long and the maximum of which is about 1,500,000 kilometers long. A mass projected into the field of force within this spheroid will describe an ellipse, parabola, or hyperbola (returning to the earth in the first case), according to the velocity with which projected.

The gravity of the earth, as evidenced by the sphere of control, is the holding power of the earth so far as an atmosphere is concerned; the extent and distribution of the atmosphere will depend upon the motions of the individual molecules composing it. The motions and collisions of gaseous molecules can be treated by the methods of statistics and probabilities; and it is easily shown that at times the speeds of certain proportions of the molecules will rise above the mean velocity to given higher and higher velocities up to a theoretically infinite speed for a vanishingly small number of molecules.

The collisional zone.—No matter how great a velocity a molecule may acquire in the lower atmosphere, or how often it may do so, it can only have its motion damped again by plunging into the surrounding multitudes of molecules; in these lower levels the paths of individual molecules are very short and consequently practically straight. Higher up, where the density of the air is less and the molecules sparser, the paths between collisions become longer and slight curvatures begin to appear in response to the forces arising from the earth's attraction.

The krenal zone.—Still higher up, where the molecules are widely scattered, the curvatures grow more pronounced. When the scattered condition becomes still greater, the earth's gravity may stop the outward flight

[2] It would seem that other factors also enter into bringing about this condition. See W. J. Humphreys, "The coldest air covers the warmest earth," in *A Bundle of Meteorological Paradoxes,* Jour. Wash. Acad. Sci., 10, 153–171, 1920 (abstracted in MONTHLY WEATHER REVIEW, 47, 876, 1919). For the probable movements of the individual molecules in the extreme upper regions, see T. C. Chamberlin, *Origin of the Earth,* Chicago, 1916, pp. 10–37.—*E. W. W.*

[1] See Hann, *Lehrbuch,* 3d ed., p. 2; Milham, *Meteorology,* p. 20; MONTHLY WEATHER REVIEW, 47, 452, 1919.